BMS 101

Inputs & Outputs

Project Base Camp Training Module

Understanding the Foundation of Building Management Systems

Learning Objectives

By the end of this module, you will be able to:

- Clearly identify and distinguish between inputs and outputs
- Understand the four types of I/O: AI, DI, AO, and DO
- Recognise common applications for each I/O type
- Extract I/O requirements from operation descriptions
- Apply I/O knowledge across all project stages

The Fundamental Concept

INPUTS

Points that are **READ ONLY**

The controller monitors these points but cannot change their values

OUTPUTS

Points that are **COMMANDED**

The controller actively controls these based on logic and conditions

Key Principle: If you can clearly identify your inputs and outputs, you're going in the right direction

Four Types of I/O

AI Analog Input

Variable values (not just on/off)

Temperature, pressure, humidity

DI Digital Input

Binary states (on/off, true/false)

Status, switches, alarms

AO Analog Output

Variable control signals (0-10V)

Valves, dampers, VSD speed

DO Digital Output

Binary control (on/off commands)

Pumps, fans, relays, contactors

Remember: **Inputs** are read by the controller • **Outputs** are commanded by the controller

Analog Inputs (AI)

Definition

Any input where the value is **variable and not just true or false**. Typically sensor inputs that measure physical properties.

Common Examples

- Room Temperature Sensor
- Water Temperature Sensor
- Duct Pressure Sensor
- Water Level Sensor
- Room Humidity Sensor
- Room Air Quality Sensor
- AHU Air Temperature Sensor
- AHU Air Humidity Sensor
- Outside Air Temperature Sensor

Technical Note: Controllers read resistance from thermistors or voltage signals (0-10V, 4-20mA) and convert them to meaningful values

Digital Inputs (DI)

Definition

A point that can be one of **two states only**: true/false, on/off, open/closed, 1/0. Typically status inputs or fault monitoring.

Common Examples

- Fire Alarm Input
- Water Tank Low Level Switch
- Boiler Fault Status
- High Temperature Thermostat
- Air Differential Pressure Switch
- Occupancy Sensor
- Low Water Pressure Switch
- Emergency Stop Button
- Pump Differential Flow Switch

Key Point: Fire alarm is always digital because it's either activated or not—there's no in-between state

Analog Outputs (AO)

Definition

A point that the controller commands **across a variable range** (typically 0-10Vdc). Used to control modulating devices that need precise positioning.

Common Examples

- Heating Coil Valve Actuator
- VAV Box Damper Control
- Burner Modulation Control
- Heat Recovery Damper Actuator
- VSD Fan Speed Control
- Chilled Water Valve Actuator
- Fresh Air Damper Actuator
- Exhaust Air Damper Actuator
- Heating Thyristor 0-10v Control

Control Example: A heating valve on a supply air unit can be positioned anywhere between fully closed (0V) and 100% open (10V) to maintain setpoint

Digital Outputs (DO)

Definition

A point used to control anything that is **either on or off**. The controller commands equipment to start/stop based on operating conditions.

Common Examples

- Fixed Speed Heating Pump
- Instant Hot Water Heater
- Standard Lighting On/Off
- Extract Fan Enable
- Supply Fan Enable
- Heating Boiler Enable
- VSD Speed Control Enable
- Raise/Lower Zone Control Valve
- Gas Water Heater Enable

Control Example: When heating is required, the pump is switched ON. When no longer needed, the pump is switched OFF

Digital Outputs: Relay vs. Triac

RELAY

✓ Electromechanical device

✓ Makes audible "click" when energized

✗ Has moving parts that wear out

✗ Finite number of operations

✗ Limited life cycle

TRIAC

✓ Solid-state electronic switch

✓ Silent operation (no click)

✓ No moving parts

✓ Long life cycle

✓ Ideal for PWM applications

PWM (Pulse Width Modulation): Uses two digital output channels to drive actuators 0-100% by rapidly switching on/off. Controller knows actuator Raise/Lower Drive Time and periodically re-strokes for calibration (Older control software doesn't do this).

Practical Example: Identifying I/O

> *"The hot water control valve will be opened whenever there is a time scheduled output enabled and a heat demand from the control thermostat installed within the storage cylinder. The valve will be immediately closed if the high temperature thermostat is operated."*

Breaking It Down

[OUTPUT] "The hot water control valve will be opened" → **AO - Analog Output**

[INPUT] "Heat demand from control thermostat" → **DI - Digital Input**

[INPUT] "High temperature thermostat is operated" → **DI - Digital Input**

Logic: Output [1] = True IF Input [2] = True AND Input [3] = True (assuming fail-safe thermostat)

Result: **1 Output** controlled by **2 Inputs**

Why I/O Knowledge Matters

Sales Engineer (Tender Stage)

Must accurately count points to select correct controllers, calculate hardware costs, and determine licensing requirements.
Missing points = cost overruns.

Project Engineer (Design & Documentation)

Creates documentation, control panel strategies, and electrical installations - all revolving around points.
A well-thought-out points schedule ensures smooth execution.

Commissioning Engineer (Installation & Testing)

Uses a points schedule and drawings to verify correct installation, perform point-to-point checks, and set the system to automatic operation.

Service Engineer (Maintenance & Troubleshooting)

Often arrives with no documentation. Starting with points helps identify all sensors, check panel wiring, and discover hidden components to prevent return visits.

Applies at ALL stages of the BMS lifecycle

Control Loops & Sequences

PID Control Loops

Controllers use PID algorithms to maintain setpoints based on input readings:

Proportional (P): React to current error

Integral (I): Handle persistent errors over time

Derivative (D): Respond to rapid changes

Sequences of Operation

Step-by-step playbooks defining how systems behave under different conditions. They describe which outputs to command based on input states and operating modes.

Remember: Every BMS operation is the product of different inputs changing state to provide the controller with information to operate outputs

Troubleshooting with I/O Knowledge

The Four Key Questions

1. What are the inputs?

What is the system measuring?

2. What are the outputs?

What can the system control?

3. What is the sequence?

How should it behave?

4. What are the setpoints?

What is it trying to achieve?

Common Issues & Checks:

- Check inputs: Is sensor reading correctly? Compare BMS vs. calibrated instrument
- Check outputs: Is controller commanding correctly? Verify valve/damper positions
- Check control loop: Is PID tuned properly? Aggressive = hunting, sluggish = never reaches setpoint
- Check sequence logic: Is system in correct mode? Verify heating/cooling calls

Key Takeaways

- **Inputs** are read-only points (AI, DI) that inform the controller
- **Outputs** are commanded points (AO, DO) that the controller operates
- Understanding I/O is **essential** at every project stage
- Start every project by **identifying your points**
- Every operation is inputs changing state to command outputs

"Know your points and you'll go in the right direction"

Thank You

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